Aeronautics Safety Investment Strategy Team (ASIST)

Human Error Consequences Subteam

Final Report

Doug Arbuckle (Co-lead)
Langley Research Center
757-864-1718
p.d.arbuckle@larc.nasa.gov

Cynthia Null (Co-lead)
Ames Research Center
415-604-1260
cnull@mail.arc.nasa.gov

1.0 Domain/Charter

Charter: Human Error, not all of human factors

- Crew/Flight Operations Dept/Maintenance/Design/Manufacturing
  - ATM is specifically excluded, covered by an existing NASA/FAA IPT
  - Interface to ATM is to be considered as appropriate
- Vehicle class coverage
  - Large jets
  - Commuter aircraft (turboprops and regional jets)
  - General Aviation (single reciprocating engine to twin engine business jets)
  - Rotorcraft

Approach: For Current--Based on Fatal Accident Statistics and Industry Consensus on Problems
For Future--Based on "Future Perfect" Scenarios and discussions at Workshops II/III

2.0 Taxonomy of Issue Areas

The subteam brainstormed a list of Human Error Consequences issue areas and then arranged the list in three major categories. The three categories remained unchanged through the ASIST process. However, there were several changes to the subcategories based on inputs from other government and industry participants in the ASIST process. We created new subcategories, we added to existing subcategories , and we moved subcategories among the categories.

Categories Definitions

- Human: includes human capabilities, skills, judgment, proficiency, cultural differences, etc.
- Task: procedures, communications, decision-making, task demands, human-machine interface, teamwork, etc.
- Personal Environment: personal environment of human operator (e.g., does not include weather operations)

HUMAN

A Capabilities (what are the abilities/limitations of humans?)
- A.1 Neuromotor
- A.2 Cognitive
- A.3 Perceptual

B Skill Proficiency

C Performance Readiness
- C.1 Fatigue
- C.2 Boredom/Complacency
- C.3 Personal Stressors (e.g., marital problems, etc.)
- C.4 Self Evaluation (e.g., how well does human self assess his/her readiness?)

D Cultural Factors
- D.1 Language
- D.2 Cultural differences

TASK

- A Teamwork
- B Communications
  - B.1 Between various parties
    - B.1.1 within flight deck(if two or more person crew)
    - B.1.2 flight deck and cabin crew
    - B.1.3 flight deck and ATC
    - B.1.4 flight deck and flight operations
    - B.1.5 flight deck and maintenance
  - B.2 Documentation
    - B.2.1 Checklists
    - B.2.2 Manuals
    - B.2.3 Charts
  - B.3 "Media"
    - B.3.1 Voice
    - B.3.2 Datalink
- C Decision Making
  - C.1 Individual
  - C.2 Group
- D Human-Machine Interface and Interaction
  - D.1 Mode Confusion
  - D.2 Management of Automation
- E Situation Awareness
  - E.1 Pilot
    - E.1.1 Aviate
      - E.1.1.1 Energy
      - E.1.1.2 Mode
      - E.1.1.3 Vehicle Capabilities
      - E.1.1.4 Systems Status
    - E.1.2 Navigate
      - E.1.2.1 Terrain
      - E.1.2.2 Weather
      - E.1.2.3 Traffic
      - E.1.2.4 Vertical navigation / altitude
      - E.1.2.5 Horizontal navigation (latitude/longitude)
  - E.2 Air Traffic Controller
  - E.3 Dispatcher
  - E.4 Mechanic
- F Function/Task Allocation and Task Demand
- G Procedures
  - G.1 Design
  - G.2 Evaluation

PERSONAL ENVIRONMENT

- A Physical
  - A.1 Temperature outside human comfort
  - A.2 Noise
  - A.3 Vibration
  - A.4 Lighting
  - A.5 Oxygen
- B Organizational culture

3.0 Relationship Between HEC Issue Areas and Fatal Accident Data

The readily available statistics on fatal accidents for large jet transports, general aviation and rotorcraft are reported by various sources. These sources gather information that varies according to factors such as the country in which the fatal accident occurred, the type of vehicle involved (large jet transport, general aviation, etc.), and the manufacturer of the aircraft (e.g., most airframers have “additional” data on a fatal accident involving an aircraft they manufactured). These statistics tend to be categorized according to “what happened” instead of “why it happened.” Most accident investigations that identify “pilot error” of “human error” as a primary or major causal factor typically do not analyze why this error or errors occurred (often this is because a conclusive analysis is not possible given the available data). This is a particular problem for using the statistics to derive human error R&T investment priorities.

Given this situation, the subteam co-leaders used the “best judgement” of industry and Government experts to estimate an allocation of various accident type categorizations (one for each vehicle class as indicated) to the Human Error Consequences (HEC) issue areas defined above. In each column, we estimated the fractional contribution of the issue area to the accident type, and identified the subcategories (A, B, C, etc) within the issue area. Figures 3.1-3.3 (below) represent the final product of this effort.

	Large jets	GA	Rotorcraft	Airline (Large jet transports)		
	World-wide Fatal Accidents (Source: Boeing, p. 41)	U.S. Fatal Accidents (Source: Nall, p.10, modified per Volpe CFIT analysis)	U.S. Accidents (Source: NTSB reports)	**"Best Judgement" Allocation of Accident Causes to HEC Issue Areas**		
ACCIDENT TYPE	ALL 1991-1995	pilot-related 1995	ALL 1989-1993	HUMAN	TASK	PERSONAL ENVIRONMENT
Loss of Cntrl in Flt	27%	22%	19%	.60 [B,C]	.40 [C,D,E,F,G]	
CFIT/Collision w/ wire/obj/gnd	29%	16%	10%	.20 [C]	.60 [B,C,D,E,F]	.20 [B]
Fire	2%			not applicable	not applicable	not applicable
Mid-Air	2%		1%	.20 [C]	.80 [B,D,E]	
Landing	12%	3%		.30 [C]	.60 [B,C,D,E,F]	.10 [B]
Ice/Snow	5%	24%		.30 [B,C]	.70 [B,C,D,E]	
Wind Shear	3%			.30 [B,C]	.70 [B,C,D,E]	
Take-off/ climb		13%				
Approach		9%				
Go-around		3%				
PILOT ERROR-misc			25%			
PILOT ERROR-power			7%			
PILOT ERROR (weather)			6%			
Systems/Hardware failure			18%			
Other	8%	7%	10%	?	?	?
Runway incursion	7%			.20 [C]	.80 [B,C,D,E,F,G]	
Fuel mgmnt	5%	3%	4%	.20 [C]	.20 [B,C,E]	.60 [B]
TOTAL	100%	100%	100%			

Figure 3.1. Relationship of Large Jet Transport Accident Data to HEC Issue Areas

	Large jets	GA	Rotorcraft	**General Aviation**		
	World-wide Fatal Accidents (Source: Boeing, p. 41)	U.S. Fatal Accidents (Source: Nall, p.10 , modified per Volpe CFIT analysis)	U.S. Accidents (Source: NTSB reports)	**"Best Judgement" Allocation of Accident Causes to HEC Issue Areas**		
ACCIDENT TYPE	ALL 1991-1995	pilot-related 1995	ALL 1989-1993	HUMAN	TASK	PERSONAL ENVIRONMENT
Loss of Cntrl in Flt	27%	22%	19%	.70 [B]	.30 [C,D,E,F]	
CFIT/Collision w/ wire/obj/gnd	29%	16%	10%	.30 [C]	.60 [B,C,D,E,F]	.10 [A]
Fire	2%					
Mid-Air	2%		1%			
Landing	12%	3%		.60 [B]	.30 [B,C,D,E]	.10 [A]
Ice/Snow	5%	24%		.30 [B]	.50 [B,C,D,E,F]	.20 [A]
Wind Shear	3%					
Take-off/ climb		13%		.50 [B]	.50 [D,E,F]	
Approach		9%		.50 [B]	.50 [C,D,E,F]	
Go-around		3%		.60 [B]	.30 [C,D,E,F]	.10 [A]
PILOT ERROR-misc			25%			
PILOT ERROR-power			7%			
PILOT ERROR (weather)			6%			
Systems/Hardware failure			18%			
Other	8%	7%	10%	?	?	?
Runway incursion	7%					
Fuel mgmnt	5%	3%	4%	.50 [B]	.50 [C,D,E]	
TOTAL	100%	100%	100%			

Figure 3.2. Relationship of General Aviation Accident Data to HEC Issue Areas

	Large jets	GA	Rotorcraft	**Rotorcraft**		
	World-wide Fatal Accidents (Source: Boeing, p. 41)	U.S. Fatal Accidents (Source: Nall, p.10 , modified per Volpe CFIT analysis)	U.S. Accidents (Source: NTSB reports)	**"Best Judgement" Allocation of Accident Causes to HEC Issue Areas**		
ACCIDENT TYPE	ALL 1991-1995	pilot related-1995	ALL 1989-1993	HUMAN	TASK	PERSONAL ENVIRONMENT
Loss of Cntrl in Flt	27%	22%	19%	.40 [B]	.60 [C,D,E,G]	
CFIT/Collision w/ wire/obj/gnd	29%	16%	10%	.60 [A,B,C]	.40 [C,D,E,F]	
Fire	2%					
Mid-Air	2%		1%	.5 [C]	.5 [C,D,E]	
Landing	12%	3%				
Ice/Snow	5%	24%				
Wind Shear	3%					
Take-off/ climb		13%				
Approach		9%				
Go-around		3%				
PILOT ERROR-misc			25%	.50 [A,B,C,D]	.40 [A,B,C,D,E,F,G]	.10 [A,B]
PILOT ERROR-power			7%	.50 [B]	.50 [C,D,E]	
PILOT ERROR (weather)			6%	.33 [B,C]	.33 [A,B,C,D,E,F]	.33 [B]
Systems/Hardware failure			18%	.50 [B,C]	.30 [C,D,E,F,G]	.2 [B]
Other	8%	7%	10%			
Runway incursion	7%					
Fuel mgmnt	5%	3%	4%	.50 [B,C]	.25 [C,D,E,F]	.25 [B]
TOTAL	100%	100%	100%			

Figure 3.3. Relationship of Rotorcraft Accident Data to HEC Issue Areas

4.0 Current and Future Need Assessment

A set of generic solutions/interventions were developed to address the Human Error Consequences issue areas defined above. These solutions/interventions are:

- **Selection and Training** of aviation human operators (pilots, dispatchers, mechanics, etc)
- **Procedures** used by these human operators in performing tasks
- **Roles and Responsibilities** of these human operators as they interact with each other
- **Metrics and Models for Evaluation** of human operator performance, including design evaluation of systems used by humans (both usability and error susceptibility)
- **System Design** to better support the human operator accomplish a task or set of tasks
- **New System or Technology** that provides additional functionality to support the human operator
- **Scheduling** human operator duty cycles to better assure maximum performance potential

A “Needs” matrix for each vehicle class (large jets, general aviation, and rotorcraft) and issue timeframe (current and future) was created using the HEC issue areas as rows and the solutions/interventions as columns. The initial matrices were created by surveying participants at ASIST workshop III as follows. First, the participants were asked to prioritize the issue areas (rows). Then, for each issue area, the participants were asked to identify priorities for solutions/interventions. This data was used to generate a set of six matrices which were distributed to the HEC subteam Government and industry attendees for comments. This was done recognizing that the process for collecting the data probably yielded an answer that was not fully representative of the Government and industry constituencies. After receiving inputs from various Government and industry participants, the subteam co-leaders subsequently adjusted the matrices to more accurately reflect the consensus views of the aviation community. The “final” matrices are shown below as Figures 4.1-4.6.

It should be noted that the subteam co-leaders view these matrices as being most accurate in totality for large jet transports (a community well-represented in the ASIST process). For the general aviation and rotorcraft matrices, the subteam co-leaders focused on assuring that “Needs” unique to these vehicle classes (compared with large jet transports) were accurately represented, rather than assuring that the totality of the matrix was accurate. The strategy inherent in this view was that “Needs” common to all vehicle classes would be captured when Investment Areas were identified (see next section).

"Current" Need Assessment - Air Carrier	Select & Training	Proced	Roles & Respons	Metrics & Models for Evaluation	System Design	New System or Tech	Sched
	Solution or Intervention						
HUMAN							
Capabilities (neuromotor, etc)	2	3	3	2	3		3
Skill Proficiency	2	2	3	2	3		3
Performance Readiness	2	3	3	1	2	3	1
Cultural Factors	1	2	2	1	2		3
TASK							
Teamwork	3	3	2	2	2	3	
Communications	1	1	2	2	2	1	
Decision Making	1	1	2	2	2	1	
Human-Machine Interface & Interaction	1	2	2	1	1	1	
Situation Awareness	1	2	2	1	1	1	
Task Allocation, Demand and Mgmt	2	2	2	2	1	2	
Procedures	3	2	3	2	2	3	
PERSONAL ENVIRONMENT							
Physical		3		3	3	3	3
Organizational culture	2	2	2	3			3

1 High Need
2 Medium Need
3 Low or No Need
"Not applicable" problem/solution combinations

Figure 4.1. “Current” Needs - Airline Transport

Future Need Assessment - Air Carrier	Select & Training	Proced	Roles & Respons	Metrics & Models for Evaluation	System Design	New System or Tech	Sched
	Solution or Intervention						
HUMAN							
Capabilities (neuromotor, etc)	2	3	3	2	3		3
Skill Proficiency	1	2	2	2	2		3
Performance Readiness	2	3	3	2	1	3	2
Cultural Factors	1	2	2	2	1		3
TASK							
Teamwork	2	2	1	2	2	3	
Communications	2	1	1	1	1	2	
Decision Making	1	1	1	1	1	1	
Human-Machine Interface & Interaction	1	1	1	1	1	1	
Situation Awareness	1	2	1	2	1	1	
Task Allocation, Demand and Mgmt	1	1	1	2	1	2	
Procedures	3	3	2	2	3	3	
PERSONAL ENVIRONMENT							
Physical		3		3	3	3	3
Organizational culture	2	1	1	3			3

1 High Need
2 Medium Need
3 Low or No Need
"Not applicable" problem/solution combinations

Figure 4.2. Future Needs - Airline Transports

"Current" Need Assessment - GA	Select & Training	Proced	Roles & Respons	Metrics & Models for Evaluation	System Design	New System or Tech	Sched
HUMAN							
Capabilities (neuromotor, etc)	2	3	3	2	3		3
Skill Proficiency	1	3	3	2	2		3
Performance Readiness	2	3	3	3	3	3	3
Cultural Factors	3	3	3	3	3		3
TASK							
Teamwork	3	3	3	3	3	3	
Communications	1	2	3	2	2	1	
Decision Making	1	2	3	2	2	1	
Human-Machine Interface & Interaction	1	2	3	2	1	1	
Situation Awareness	1	2	3	2	1	1	
Task Allocation, Demand and Mgmt	2	2	3	2	2	2	
Procedures	3	3	3	3	3	3	
PERSONAL ENVIRONMENT							
Physical		3		2	2	3	3
Organizational culture	2	2	3	3			3

Solution or Intervention

1 High Need
2 Medium Need
3 Low or No Need
"Not applicable" problem/solution combinations

Figure 4.3. "Current" Needs - General Aviation

Future Need Assessment - General Aviation	Select & Training	Proced	Roles & Respons	Metrics & Models for Evaluation	System Design	New System or Tech	Sched
HUMAN							
Capabilities (neuromotor, etc)	3	3	3	3	3		3
Skill Proficiency	1	2	3	2	2		3
Performance Readiness	3	3	3	3	3	3	3
Cultural Factors	3	3	3	3	3		3
TASK							
Teamwork	3	3	3	3	3	3	
Communications	3	2	3	3	3	2	
Decision Making	1	3	3	2	2	1	
Human-Machine Interface & Interaction	2	3	3	2	1	1	
Situation Awareness	2	3	3	2	2	2	
Task Allocation, Demand and Mgmt	2	3	3	3	2	2	
Procedures	2	3	3	3	3	3	
PERSONAL ENVIRONMENT							
Physical		3		3	3	3	3
Organizational culture	3	3	3	3			3

Solution or Intervention

1 High Need
2 Medium Need
3 Low or No Need
"Not applicable" problem/solution combinations

Figure 4.4. Future Needs - General Aviation

"Current" Need Assessment - R/C	Solution or Intervention: Select & Training	Proced	Roles & Respons	Metrics & Models for Evaluation	System Design	New System or Tech	Sched
HUMAN							
Capabilities (neuromotor, etc)	2	3	3	2	2		3
Skill Proficiency	1	3	3	2	3		3
Performance Readiness	2	3	3	3	3	3	3
Cultural Factors	3	3	3	3	3		3
TASK							
Teamwork	3	3	3	3	3	3	
Communications	1	2	3	2	2	1	
Decision Making	1	2	3	2	2	1	
Human-Machine Interface & Interaction	1	2	3	2	1	1	
Situation Awareness	1	2	3	3	1	1	
Task Allocation, Demand and Mgmt	2	2	3	2	2	2	
Procedures	3	3	3	3	3	3	
PERSONAL ENVIRONMENT							
Physical		3		2	2	2	3
Organizational culture	2	2	3	3			3

1 High Need
2 Medium Need
3 Low or No Need
"Not applicable" problem/solution combinations

Figure 4.5. "Current" Needs - Rotorcraft

Future Need Assessment - R/C	Solution or Intervention: Select & Training	Proced	Roles & Respons	Metrics & Models for Evaluation	System Design	New System or Tech	Sched
HUMAN							
Capabilities (neuromotor, etc)	3	3	3	3	3		3
Skill Proficiency	1	2	3	3	3		3
Performance Readiness	3	3	3	2	3	3	3
Cultural Factors	3	3	3	3	3		3
TASK							
Teamwork	3	3	3	3	3	3	
Communications	2	2	2	3	2	1	
Decision Making	1	2	2	3	2	1	
Human-Machine Interface & Interaction	1	2	2	3	1	1	
Situation Awareness	1	3	3	2	1	1	
Task Allocation, Demand and Mgmt	2	2	3	3	2	1	
Procedures	3	3	3	3	3	3	
PERSONAL ENVIRONMENT							
Physical		3		3	3	3	3
Organizational culture	2	2	3	3			3

1 High Need
2 Medium Need
3 Low or No Need
"Not applicable" problem/solution combinations

Figure 4.6. Future Needs - Rotorcraft

5.0Recommended Investment Areas

The Investment Areas recommended by the HEC subteam were created by identifying the “high” and “medium” needs in the “Needs” matrices (above) and postulating appropriate R&T investments to address these needs. This process resulted in a proposed investment strategy to address current issues and one to address future issues. Also, the investment areas were largely “bubbled” up from a vehicle-class “Needs” matrix. The subteam co-leaders then examined each investment area and made a determination as to whether or not the area should address more than vehicle class.

The subteam co-leaders then developed a proposed prioritization for the investment areas according the following criteria:

- Degree of linkage to accident/incident causal factors or current/future safety problems identified by Government/industry participants in the ASIST process
- Degree to which R&T can provide a “solution” to the “problem”
- Degree to which R&T products are implementable

Note that an attempt was made to balance the portfolio of R&T investments between near-term “quick wins” and long-term “bold efforts.”

The resulting recommended Investment Areas and priorities were then formulated as shown below in Figures 5.1-5.3 and presented at ASIST Workshop IV for comment by the Government and industry attendees. Comments and feedback were received both orally in real-time at the Workshop and subsequently via e-mail from some participants. Most of these comments are captured in subsequent sections of this document.

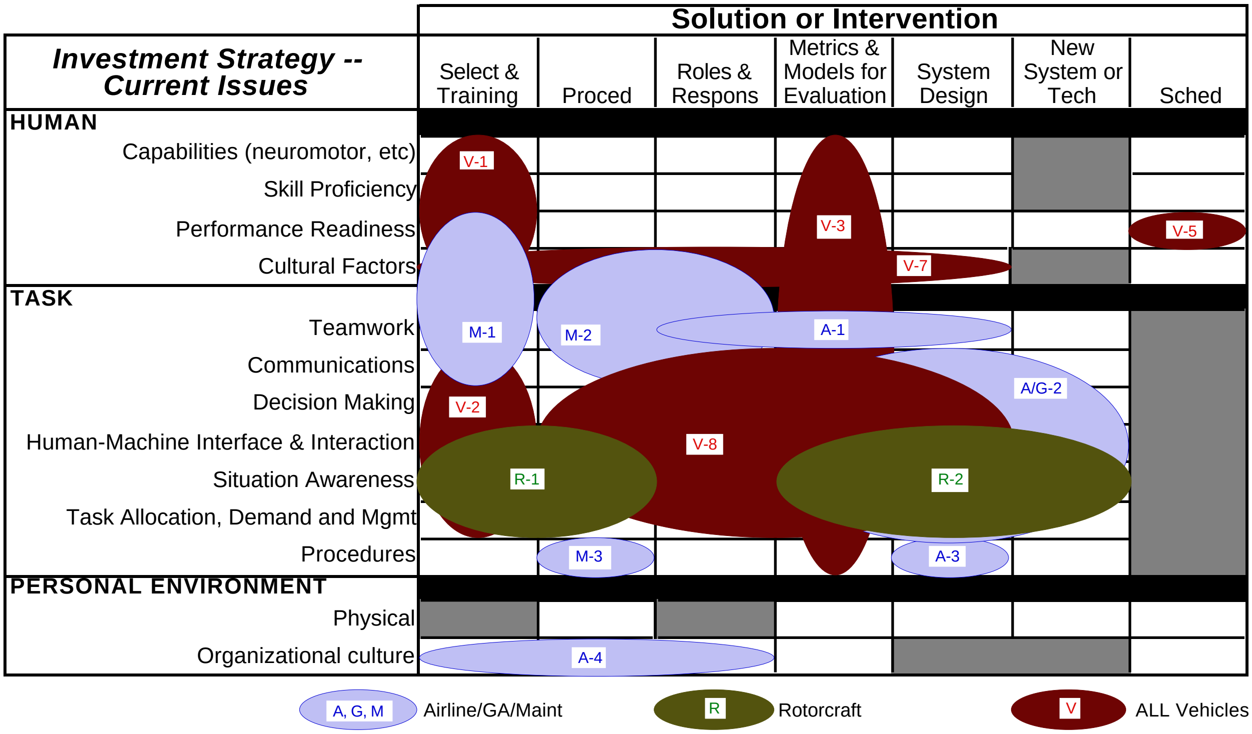

Figure 5.1. Investment Strategy - Current Issues

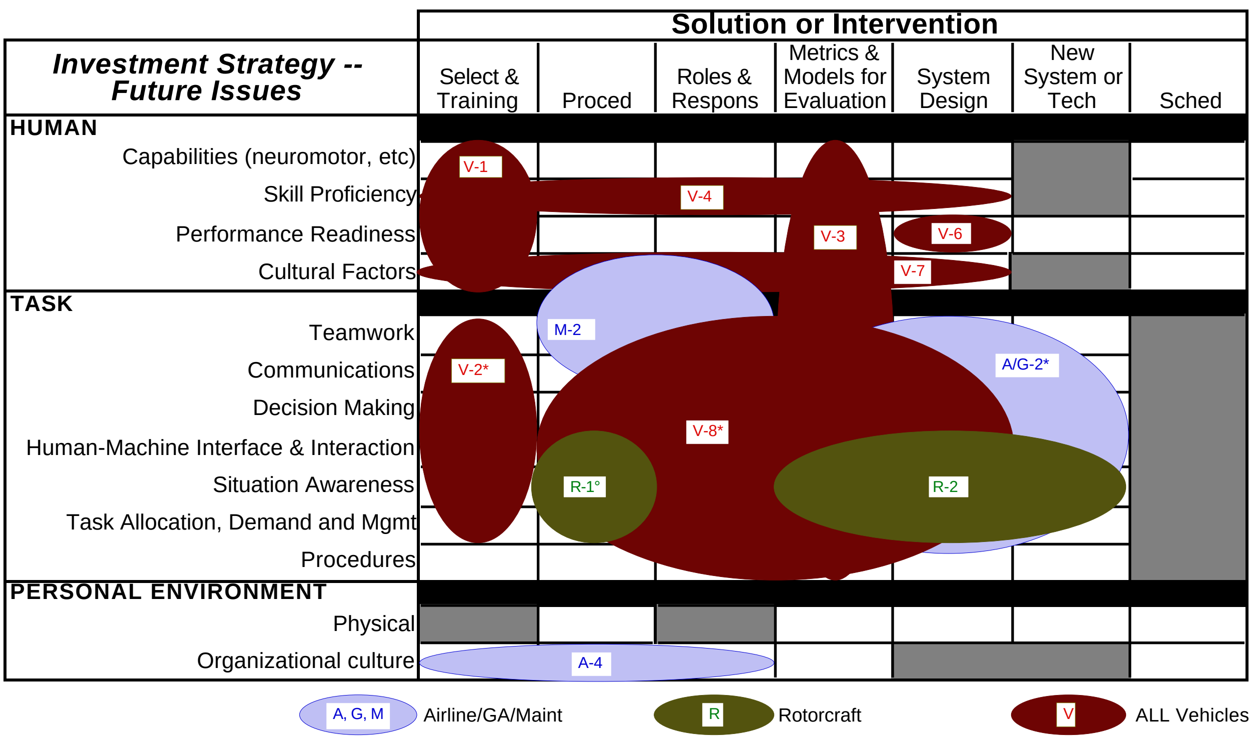

Figure 5.2. Investment Strategy - Future Issues

Code	"Investment Area" Name
V-3	Metrics & Models for Evaluation
V-2/2*	Selection & Training (Task-specific)
V-8/8*	Human/Automation Design Principles and Guidelines
A/G-2/2*	Flight Deck Design and Integration
V-4	Skill Proficiency
R-2	Rotorcraft-specific Pilot Aiding Systems
M-2	Maintenance Teamwork Procedures & Roles/Responsibilities
V-7	Cultural Factors
V-5	Fatigue and Circadian Disruption Impacts
R-1/1°	Rotorcraft-specific Procedures and Training
V-1	Selection & Training (Human - general)
A-4	Organizational Culture for Safety
M-1	Maintenance Training *(augment FAA ongoing pgm)*
A-1	Design to Support Teamwork
A-3	Procedures Design Methods
M-3	Maintenance Task Procedures
V-6	Design to Support Performance Readiness

Figure 5.3 Proposed Prioritization of Investment Areas

5.1 Descriptions of Recommended Investment Areas

Issues equally relevant to all vehicle classes ("V")

V-1 Selection and Training (Human - general)

<Addresses both "Current" and "Future" issues>

Objectives: Develop a proven methodology for selecting and initially training pilots to ensure that they will possess the cognitive, perceptual, and motor skills necessary to operate safely within the airspace projected for the 21st century. Develop candidate materials, methods and facilities for recurrent training appropriate for different operational environments and vehicle classes.

Potential products:

- Selection and training issues prompted by the changing pilot population (i.e., fewer pilots who were initially trained by the military).
- Predictors and measures of communication and decision-making skills.
- Proven methodologies for training to proficiency across training systems ranging from personal computers to full-mission, motion-based simulators and vehicle classes.
- Objective measures of training effectiveness.

V-1 Selection and Training (Human - weather)

<Addresses a "Current" issue>

Objectives: The goal of this investment area is to develop new technologies and methods for operationally-oriented weather safety training. Initial effort seeks to effectively disseminate state-of-the-art information on aviation weather and its effects on aircraft performance.

Project activities in this area are intended to supports all weather issues. One option for implementation of some of the project elements would be to use Cooperative Operational Meteorology Education and Training program (COMET) from the University Corporation for Atmospheric Research (UCAR) as a training focal point to explore, analyze, test, and help build suitable aviation weather training environments for forecasters, dispatchers, and flight crew.

V-2/2 Selection and training (Task-specific)*

<Addresses both "Current" and "Future" issues>

Objectives: Develop proven methodologies for training pilots to proficiency on new technologies, (evolutionary variations as well revolutionary changes), cockpit procedures, and air traffic management systems. Identify the most effective training system for developing the skills required to perform specific tasks (ranging from personal computers to high-fidelity simulators). Develop candidate materials, methods and facilities for recurrent training to keep pace with advances in technology and the radical changes forecasted for the national airspace.

Potential products:
- Improved methods of modeling and presenting automated systems in training to facilitate more complete understanding of system performance under varied conditions.
- Guidelines for the use of personal computers and low-to-moderate-fidelity simulators for training pilots to perform specific tasks.
- Low-cost, easily distributed methods of training pilots to use new technologies and procedures as they are introduced. Tailor such systems to the needs of specific end users (i.e., recreational GA pilots; corporate pilots; rotorcraft operators/pilots engaged in logging, agriculture, fire fighting, news/traffic reporting, emergency medical service, law enforcement; and off-shore oil operations; scheduled and and unscheduled airlines, commuters, etc).
- Low-cost, distributed methods for recurrent training.

V-3 Metrics & Models for Evaluation

<Addresses both "Current" and "Future" issues>

Objectives: The goals of this investment area are both near-term and long-term. In the near-term, develop and demonstrate metrics for evaluating the human error susceptibility of a particular training technique, operational procedure, or system design. In the long-term, the goal is to develop a model or models that allow human error susceptibility predictions to be made during the synthesis phase of system design, procedure development, and training preparation.

Potential products:
- More effective methods for recording and analyzing sequences of human behavior to obtain accurate error-frequency statistics. Error rates are difficult to accurately estimate using accident data because most errors are corrected before they have measurable consequences (accidents occur rarely).
- Techniques for tracking certain pilot and controller parameters of interest (e.g., non-intrusive eye fixation monitoring, rapidly sampled control inputs); it is difficult to validate models of pilot and controller performance with the parameters currently used.
- Quantitative measures of situation awareness to clarify which elements of the situation are incorporated into operators' representations of the world and how reasoning proceeds from known facts; methods of predicting the impact of changes in technology, procedures, airspace structure, training, etc on situation awareness.
- Measures and techniques for display-format evaluation standardized in a manner similar to that that which exists for flying qualities.
- Metrics for use in FAA certification of aircraft (airplanes and rotorcraft) crew stations or retrofits of these vehicles.
- Measures appropriate for evaluating the validity of quantitative models of aircrew and ATC decision-making.
- Models and metrics for evaluating communications demands imposed by "silent communications" techniques such as datalink.
- Models of the sequences of mental operations that underly the performance of critical flight deck and ATC tasks to characterize the contribution of cognitive processes to the generation of error.

V-4 Skill Proficiency

<Addresses a "Future" issue>

Background: In the future, two trends will converge: (1) the global airspace system will demand more performance and capabilities from the aircraft operating in it; (2) retirement of large numbers of airline pilots (many of whom were trained to fly by the military) and a miniscule influx of replacement pilots from the military. The result will be a significant number of "low-time" (relative to today) pilots operating sophisticated aircraft. The airline pilot population will not be as homogeneous as the current military-trained pilot workforce. General aviation pilots will have access to highly capable personal aircraft that will be able to operate in most of the same airspace as the airliners. Rotorcraft pilots will be operating vehicles designed to operate in all-weather conditions.

Objectives: Develop and validate: (a) metrics for measuring skill proficiency of pilots operating advanced aircraft (fixed-wing and rotorcraft); (b) training and selection methodologies designed to use the metrics to create skill-tailored training programs; (c) design methodologies that use the metrics as feedback to allocate roles and responsibilities, develop procedures, and prototype system interfaces. This will require an understanding of the relationship between system complexity and potential level of skill proficiency, as well as an understanding of the nature of skill development including its effects on task representation and error rate.

V-5 Fatigue and Circadian Disruption Impacts

<Addresses a "Current" issue>

Objectives: Complete ongoing research to define the effects of fatigue and circadian desynchrony on human performance and to recommend prevention strategies; develop and evaluate countermeasures to maximize performance and alertness during operations; develop and transfer educational tools to the aeronautics and operational communities, conduct research to investigate fatigue issues in aviation environments; and provide technical input to accident investigation methods and National policy regarding flightcrew flight/duty/rest considerations. After identifying unique issues and proposing solutions, tailor this body of research to the needs of new operational communities beyond those already approached, such as single-engine fixed-wing and helicopter pilots, maintainers, dispatchers, etc.

Potential products:
- Database relating physiological, performance, behavioral, and self-report measures of fatigue
- Scheduling tools for flight crew, ground crew, AOC and so forth
- Model relationship of physiological states and performance
- Adapt available knowledge and training methods for fatigue management to the rotorcraft, GA , and maintenance communities

V-6 Design to Support Performance Readiness

<Addresses a "Future" issue>

Objectives: This investment area examines how performance readiness issues could be addressed in design of a system or systems operated by a human. Some ideas for this are listed under "Potential products" below.
Based on feedback from the ASIST Human Error Consequences subteam during and subsequent to Workshop IV, investment areas V-8, A/G-2, and possibly R-2, should be expanded in scope to include this investment area (thus removing the need for it as a separate investment).

Potential products:
- Systems whose operations are less sensitive to degradation in human performance readiness
- Systems designed to detect degradation in human performance readiness
- Systems that can adapt system functions to help the human operator raise performance readiness (only applicable to certain classes of performance readiness, such as boredom or complacency)

V-7 Cultural Factors

<Addresses both "Current" and "Future" issues>

Background: Culture can be defined as the norms, attitudes, values and practices that members of a nation, organization, profession or other group of people share. In this investment area, the focus is more on individuals who come from national or multi-national cultural groups. In this context, these groups can have language differences that are often related to the cultural differences that exist among various national or multi-national groups.

Objectives: Develop and validate a framework for identifying relevant cultural differences (in the aviation context) and understanding how cultural and language differences affect the performance of human operators in aviation. This includes both differences experienced between two or more operational entities and between system designers and operators.

Potential products:
- Standardized verbal communication protocols for non-native English speakers, both within flight decks and between flight crew and ATC.
- Internationally standardized flight deck symbology used in lieu of words on instrument panels and displays.
- Understand the response of different cultures to authority hierarchies in different work environments. An example might be comparing and understanding the operating models of Asian versus European versus U.S. flightcrew members.
- Procedures that take account of cultural differences in risk assessment and decision making.
- Explicit models for how culture or computer literacy affects the human operator view of automation.

V-8/8 Human/Automation Design Principles & Guidelines*

<Addresses both "Current" and "Future" issues>

Objectives: Develop and validate a human/automation design principles and guidelines that are applicable to the various levels of automation that support all of the humans in aviation. Adopt a complete systems approach that encompasses design, procedures, training, and measures of effectiveness. Explicitly include cultural factors, teamwork issues, performance readiness and so on as well as modes of system use. Aim the design principles and guidelines that are developed at both preventing errors from occurring as well as "trapping" those that do occur.

Potential products:
- Methods for incorporating known human factors principles into the design process.
- Models of shared human-machine monitoring and decision-making that emphasize the effects of shared responsibilities and delineate roles and responsibilities.
- Impact of system design and re-design on training.
- Definition of human/automation design methodology that supports retrofit systems integration as well as new design concepts and is applicable to automation that supports all humans in aviation (pilots, dispatchers, controllers, and mechanics).
- Relationship between performance with different levels and types of automation and level of training based on empirical data.
- Impact of cultural factors on human/automation operations.
- Understand the effect of automation on distributed work environments, including development of formal models of procedure adequacy and communications in distributed work environments.

Issues particularly relevant to airlines ("A") and GA ("G")

A-1 Design to Support Teamwork

<Addresses a "Current" issue>

Objectives: This is a near-term investment that builds the technology base for future leveraging by "Human/Automation Design Principles and Guidelines" (V-8) and "Flight Deck Design and Integration" (A/G-2). The activity is focused on airline operations and includes interactions among and between pilots, dispatchers, mechanics and controllers (interactions with flight crews and airline operations centers only). The goals are to develop and validate metrics and models for team performance in accomplishing a task or set of tasks, to postulate appropriate roles and responsibilities for individual team members and a team unit, and to investigate the implications on the design process of explicitly considering teamwork as a design requirement.

Potential products:
- Models and metrics for representing and analyzing information flow and communication demands in team work environments.
- Metrics and techniques for assessing team performance.
- Models or guidelines for allocating roles and responsibilities to optimize teamwork and performance.
- Methodology to explicitly specify teamwork requirements for use in system design.

A/G-2/2 Flight Deck Design and Integration*

<Addresses both "Current" and "Future" issues>

Objectives: This investment area is aimed at developing and validating a top-down, human-centered methodology for flight deck design and systems retrofit that will improve pilot performance and/or reduce training requirements.

The methodology will build on the human-centered philosophy work of Billings and the flight deck design philosophy work conducted under the HSR program. The methodology will support both design and integration of retrofit systems into existing flight decks as well as design of new flight deck concepts. Other desired attributes of the design methodology:
- Provide better flight crew awareness by reflecting mental models in the design and providing information at the level of usage.
- Improve flight crew engagement by increasing their interaction with the flight deck systems (in appropriate ways) without increasing workload.
- Provide involved control of the flight crew over all flight parameters (not just override capability).
- Define the roles, functions, and responsibilities of the flight crew in terms of the mission (instead of in terms of the equipment).
- Reduce the number of modes; integrate information; and insure format, context, and procedure consistency.
- Provide integrated training and procedures.

A-3 Procedures Design Methods

<Addresses a "Current" issue>

Objectives: Incorporate models of operational procedures into the design phase in order to understand the system-wide impacts of new, modified, or retrofitted technology. Develop and apply models of shared responsibilities and delineate roles and responsibilities. Relevant principles could be adapted to rotorcraft and general aviation application in a subsequent investment area.

Potential products:
- Models of shared human-machine monitoring and decision-making.
- Improved understanding of the impact of system design on procedures including the effecs of redesign.
- Models of operational procedures for use during system design.
- Formal methods for developing and testing procedures for distributed work environments that incorporate significant levels of automation.

A-4 Organizational Culture for Safety

<Addresses both "Current" and "Future" issues>

Objectives: Develop and validate a framework for instilling and maintaining an organization-wide safety culture appropriate for different types of operators.

Potential products:
- Analysis of the incentives that exist within the FAA and airlines that affect decisions related to safety, profit, and efficiency.
- Publish an "organization safety culture checklist" that provides guidance to organizations on the steps that must be taken to establish and maintain a safety culture.
- With industry, develop methods of encouraging the evolution of a "safety culture" within the rotorcraft and general aviation communities.

Issues Particularly Relevant to Maintenance ("M")

M-1 Maintenance Training

<Addresses a "Current" issue>

Objectives: Redesign training programs for mechanics to be relevant to the tasks they are to perform and that are tailored to the changing workforce. Assess current and proposed training methods, as well as the impact of changes in procedures and/or technologies on performance.

Potential products:
- Updated curriculum that reflects realistic needs and new-technology aircraft, equipment, tools
- On the job, recurrent, and just-in-time training programs structured and standardized to accommodate changing and growing workforce
- Modularized training that fits the diverse and distributed workforce and different skill levels
- Management and supervisory training for changing work and workforce
- Metrics to evaluate performance-based training and to compare team performance and workload under various conditions and for alternative processes
- Methodology thats reflect the system as a whole as well as the contributions of individuals; complex operations must be evaluated by understanding the interdependence of processes.

M-2 Maintenance Teamwork Procedures, Roles & Responsibilities

<Addresses both "Current" and "Future" issues>

Objectives: Identify improvements in teamwork, communications, and procedures for fixed- and rotary-wing mechanics that will improve safety and while maintaining efficiency. Improve and standardize verbal and written communications to facilitate the transfer of relevant information within and across teams and organization, with particular emphasis on the requirements imposed by increases in the complexity of equipment, aircraft, and organizations. As the number of organizations involved in maintenance increases, communication will become even more important to avoid the increased opportunity for misunderstandings.

Potential products:
- Modify job descriptions to reflect an increase in vendor and service contractor participation; jobs are increasingly handled by multiple organizations (through out-sourcing) in which the work environment differs (by culture, procedures, and policies)
- Develop methods to track task status and work distribution from team to team and shift to shift

M-3 Maintenance Task procedures

<Addresses a "Current" issue>

Objectives: Identify the root causes of human errors in maintenance operations. Maintenance errors are often latent and invisible (i.e., they may occur at a time and place quite distant from the maintenance work itself). Thus, methods of characterizing and resolving these kind of errors must be identified. This process must involve teams outside the maintenance operations (flightcrews, ground handlers, shipping, inspectors, service contractors) as well as maintainance managers and personnel. Based upon the results of this analysis, identify procedures in need of improvement. As needed, propose alternative or modified procedures, adopting a systems approach and involving members of the workforce to ensure acceptance.

Potential products:
- Incident/accident database and associated analyses that identify root causes and characterize the relevant processes with respect to human factors and risk factors tied to operational data
- Improved procedures that incorporate human factors principles, have a team perspective as well as a systems perspective, and smooth the transition from one process to within and across teams and shifts
- Electronic technologies to facilitate routine updating of procedures, as required

Issues Particularly Relevant to Rotorcraft ("R")

R-1/1° Rotorcraft-specific Procedures & Training

<Addresses both "Current" and "Future" issues>

Objectives: Transfer the results of previously performed NASA research to industry in the form of training modules. As part of the process of developing or funding the development of new technolgies, consider the initial and recurrent training impact and provide support for industry trainers. Develop more efficient methods for recurrent helicopter pilot training using low-cost technologies that can be easily distributed to crew bases. Encourage a shift toward the use of simulators for initial and recurrent training to reduce the exposure for instructional flying accidents.

Potential products:
- Package and transfer results of relevant NASA research to industry training programs
- Develop improved methods of training pilots for avoidable errors (e.g., loss of situation awareness; inadvertant entry into IMC & controlled airspace; failure to respond appropriately to system/structure failures)
- Low-cost, distributed methods for recurrent training
- Establish the benefits of using simulators for helicopter pilot training

R-2 Rotorcraft-specific Pilot Aiding Systems

<Addresses both "Current" and "Future" issues>

Objectives: To improve the quality of pilot performance and reduce periods of high workload, develop computational aids and well-designed displays to provide needed information at the appropriate time and in a format that may be comprehended easily and accurately. Taking advantage of lessons learned by DoD and civil transport, avoid the introduction of "clumsy automation" and instead offer automated features that are "human-centered".

Potential products:
- Aids/displays to avoid inadvertant entry into IMC conditions
- Pilot-associate-type technologies to reduce pilot workload
- Improved methods of incorporating procedures for new technologies into the current system
- Pilot aids for envelope limiting

5.2 Grouping Recommended Investment Areas for Program Planning

The HEC subteam co-leaders believe that the Recommended Investment Areas should be grouped as follows for NASA program planning purposes:

1. Evaluation Metrics and Models
   - V-3 Metrics & Models for Evaluation
2. Design Principles
   - V-8/8* Human/Automation Design Principles & Guidelines
   - V-6 Design to Support Performance Readiness
   - V-7 Cultural Factors
   - V-4 Skill Proficiency
   - A-3 Procedures Design Methods
   - A-1 Design to Support Teamwork
3. Training
   - V-2/2* Selection and Training (Task-specific)
   - V-1 Selection and Training (Human - specific)
   - R-1/1° Rotorcraft-specific Procedures and Training
   - V-4 Skill Proficiency
4. Design and Integration
   - A/G-2/2* Flight Deck Design and Integration
   - R-2 Rotorcraft-specific Pilot Aiding Systems
   - V-6 Design to Support Performance Readiness
   - V-7 Cultural Factors
   - V-4 Skill Proficiency
   - A-3 Procedures Design Methods
   - A-1 Design to Support Teamwork
5. Maintenance
   - M-2 Maintenance Teamwork Procedures, Roles & Responsibilities
   - M-1 Maintenance Training
   - M-3 Maintenance Task procedures
6. Fatigue and Performance Readiness
   - V-5 Fatigue and Circadian Disruption Impacts
   - V-6 Design to Support Performance Readiness
7. Organizational Safety Culture
   - A-4 Organizational Culture for Safety

Note that some of the Recommended Investment Areas are to be considered by multiple planning teams. These cases all involve single problem areas in the Need matrix, where the problem area needs to be considered by the planning team.

6.0Notes from HEC subteam meetings at ASIST Workshops I through IV

6.1 Issues discussed at Workshop I

- Data
  - *Safety data is key since it will be used to make investment decisions according to two criteria:*
    + What are the big safety issues?
    + What can NASA R&T accomplish toward fixing a given issue?
  - How to establish baseline?
  - What data is useful?
    + Accident reports
    + Incident reports
    + Other accident precursors
      > FOQA data
      > Captain's reports
    + Difficulties encountered in Training
      > Collection and analysis of LOFT sessions
    + How do different data sources compare?
      Accidents vs Incidents vs Other precursors vs Training difficulties
    + Annual accident rate is not the sole metric of safety level
      > In U.S., accidents are infrequent
      > Nature of accidents is stochastic (FAA "multiple spinning wheels with holes" analogy)
      > Therefore, need more than annual measurement of accident rate to determine level of safety improvements in U.S. (using U.S. accident rate alone, will have to wait 10-15 years)
  - Data sharing issues
    + Legal
    + Political
    + Public perception
    + Analysis methods for differently structures and content in databases

- Future issue areas
  - "Free Flight" operations impact on Human Error Consequences
  - Flight 2000
  - Changing demographics/experience of airline flight crews (not homogeneous population)
    + "pipeline from military" no longer significant
    + Developing country and other non-US considerations

6.2 Issues discussed at Workshop II

- Maintenance, AOC, and Ramp Operations have not been adequately addressed by our team so far
  - Data is an issue
    - have not been able to find a good database on what the problems are
    - not many (if any) accidents where maintenance or AOC human error is a major causal factor
    - ramp accidents usually aren't fatal, and they aren't included in the Boeing/Douglas databases
  - Need to make sure we don't lose track of these issues

- CFIT is an unsatisfactory category for accidents
  - Umbrella category that would benefit from subcategorization
  - A "what" category, not a "why" category
  - Problem is that large transport industry commonly uses the term, so can't escape it completely
  - Don Sussman (Volpe) will send us an analysis of CFIT accidents for general aviation

- Future Scenarios
  - Each scenario needs more detail to be useful
    - roles and responsibilities description in Air Traffic and Flight Planning areas
    - describe relationship of scenarios to "existing" Free Flight concepts
  - Comments on or additions to 5 year Scenario
    - Stage 3 impact on fleet mix and/or retrofit plans
    - FMS-based and/or GPS-based navigation everywhere
    - Trend toward pilots having to pay for training for their type rating to be hired
    - Pilot demographics need to be addressed
      - "pipeline from military" no longer significant
      - older average age during this time period
      - higher percentage of non-native English speakers in US airspace
      - Developing country and other non-US considerations
    - Regional carriers need to be addressed
      - higher fraction of regional airplanes in US, particularly for short stage lengths
      - proliferation of aircraft types
      - increasing sophistication of airplanes operated by regional carriers, including jets
    - "single-pilot rule for air taxi"
    - significant influx of military surplus helicopters, mostly flying in uncontrolled airspace
  - Comments on or additions to 10+ year Scenario
    - Incorporate appropriate comments made on 5 year Scenario
    - Traffic is expected to double in the next 12 years and triple in 20 years
    - Pilot demographics need to be addressed (changes from above)
      - younger average age during this time period (older group retired out)
      - higher computer literacy
    - Automation introduction in rotorcraft fleet -- same or different problems to fixed-wing?
    - Impact of General Aviation Propulsion program
      - Significant (or larger) numbers of single pilot GA airplanes flying at 30,000 ft

Issues discussed at Workshop II (continued)

- General issue discussion
  - Changing “core competencies” of pilots?
    + What are they?
    + What should they be?
  - Will changing role of pilots from “stick and rudder pilots” to “automation managers” decrease the appeal of the profession? If so, will this cause less competent, motivated individuals to be attracted to the profession?
  - How do we know a good design? Have not captured what we know in a useable form for FAA Certification
  - Strategic versus Tactical Situation Awareness
  - Training
    + What fidelity is appropriate and how to determine?
    + How to measure pilot performance?
    + Can we “design for training”?
  - Proliferation of warning information on flight deck
  - Roles and Responsibilities among critical components
    + Pilots with Flight Deck automation and Controllers
    + Controllers with ATM automation and Pilots
  - Regional carriers training their crews to part 121 standards
    + Lower cost approach is needed, can be achieved multiple ways
  - Impact of varying airspace capabilities and rules
    + within US as new functions are introduced
    + Harmonization across global regions, including CIS versus non-CIS

6.3 Issues discussed at Workshop III

- Data-driven versus Future issues
  - Accident data is descriptive, not predictive
  - Industry has pretty good track record at responding to lessons learned in accidents
    + NASA has participated as a member of industry when appropriate
    + NASA is not a primary player in most "accident response" cases
  - NASA should maintain some reasonable balance between being Accident-data-driven and oriented toward Future issues
  - Big discussion about data
    + Concern about NASA's focus on accident data
    + Need to get away from thinking about accident and incident data collection and establish baseline for system performance and monitor exceedances/anomalies
    + What will NASA do if the community doesn't solve the "data adequacy problem"? An alternative path is needed

- Criteria for prioritizing proposed R&T investments ("Null test")
  - Degree of linkage to accident/incident causal factors or safety problems identified by industry consensus
  - Degree to which R&T can provide a "solution" to the "problem"
  - Degree to which R&T products are implementable

- R&T ideas
  - AR (Augmented Reality?) manuals, etc. for maintenance (registration with real-world) >>SA w/ New Sys/Proc/Trng
  - Human performance monitoring >> Perf Read w/ Trng
  - Decision-making aids (Electronic checklist) >> Decision-making w/ Proc/New Sys
  - RTO problem: Sol'ns could be decision aids, augmentation systems, training
  - Reduce number of 1st level (critical) items pilot must do when something goes wrong
  - Allow erroneous actions to be reversed easily and quickly
  - Airplane tells you what is broken -- exists on B-777, big issue for how to retrofit
  - Inappropriate crew response to propulsion system anomalies or failures
  - Understandability of communications and aural flight deck alerts for non-native language speakers
    + standard phraselogy for pilot/ATC communications (datalink won't make this go away)
  - Need to get smarter about humans and how they perform
    + what are the factors and how do they effect crew decision-making and performance
    + need to understandwhy things happen and under what conditions
    + failure recognition by humans
    + variability of a given human over time and different environmental conditions
  - Datalink "party line" issue -- are we doing enough? Probably not.
  - Impact of capability that imaging sensors may provide -- sensor/data fusion
  - Display integration
    + Traffic, terrain, weather, flight path info on a 5" display with six colors
    + Display clutter and declutter options
    + Information integration -- will pilot be left with the bag?
  - Mixed fleet capability and differing info available to different system elements
    + pilots have different charts across different airplane types
    + pilots have different charts from controllers

Issues discussed at Workshop III (continued)

- Current Issues
  - Need more attention to retrofitting “classic” flight decks like late model 747-300’s that will be flying for awhile
    - + Is this an issue for NASA to address?
    - + Industry view that there is large leverage to be had here with respect to accident rate
  - Long-range aircraft create proficiency issues since much fewer takeoffs/landings
  - Increasing automation and more reliable systems lead to proficiency concerns in emergencies
  - Integration issues for retrofitting older digital aircraft (federated architectures not easy to add components to)
  - Younger pilots who did not come up through military are more vulnerable to failures of glass cockpit functions (not maintaining awareness of where they are that is independent of the FMS-based functionality)
  - How to test for knowledge of automation systems and different flight deck modes including degraded functionality in presence of failures -- check rides are not covering either automation system knowledge or degraded modes
  - Tradeoff between good “stick and rudder” skills and “automation management” skills -- can one human be good at both?
    - + different skills
    - + not necessarily incompatible skills
  - Electronic Library System issues
    - + crews print out too many datalinked messages since electronic information retrieval mechanism in flight deck is poor
    - + causes too much heads-down time
  - Education level of maintenance technicians in third world countries
    - + how to train
    - + how to know when proficiency achieved
  - Implications of highly reliable systems on maintenance inspection approaches
  - Need more understanding of roles allocation between pilots/humans and automation

Issues discussed at Workshop III (continued)

- Future Issues
  - No major new airports will mean more pressure to increase airport and terminal area traffic density
    + where the traffic is + wake vortex
    + communication requirements can only be met with datalink -> loss of party line info
    + 4D clearances + VNAV
    + tighter flight path tolerances for traffic and noise impact issues
    + traffic density on airport surface -> will require all-weather capability for taxi
      > cannot require all ground vehicles to have transponder -> sensors required
    + more pressure to land in lower minimums
    + more pressures on pilots to make the landing and not execute a missed approach
    + how to integrate information that will be flowing into flight deck
    + heads-down time requirements to use existing on-board systems to maintain tighter airspace tolerances in more dynamic environment
  - Ground servicing in high density future
    + pressure to turn around vehicles more quickly
    + how to service aircraft more quickly and efficiently -- what can be done to help these crews?
      > new systems and technology
      > fresh look at concept of operations for servicing
    + Master Minimum Equipment List (MMEL) getting more complex with modern aircraft -- decision-aid may be required
  - Aviation system implications of revolution in air traffic controller position
  - Free Flight
    + how to transition between operating modes
    + changes in roles and responsibilities and training and/or task demand implications
    + mixed equippage will lead to differences in the ways that traffic is handled
    + nonuniform implementation of the concept across the globe -- major danger could be the subtle differences and failure to recognize the subtleties by less proficient pilots
    + what do different CNS/ATM implementations mean to the operators? NASA could play a major role here.
  - Military flight decks falling behind airline transports
    + CDTI, TCAS, datalink communications, etc
  - More hostile world with rising terrorism
    + Cameras being put on airplane to provide external views for taxi aiding and passenger entertainment
      > implications for potential hostage rescues (how do the commandos get in without being seen by the terrorists?)
    + Interest of some airlines in having flight crews monitor passenger cabin activities
    + We do not yet understand all of the issues here
  - What will happen with GA? Will market remain static or will revitalization occur?
  - Push for single pilot operations in regional/commuter aircraft -> Part 121 carriers (no consensus among group on the timeframe for this -- ranging from a decade to never)
  - De-icing inspection approaches for the future
    + Manual inspection is problematic now
    + Not practical for some future configurations (Blended Wing Body, High Speed Civil Transport)
  - HSCT vehicle-induced issues for flight crew error
    + inlet system handling by pilot and effect on engine unstart
      > crew not proficient in how to fly the airplane to avoid this
      > crew not proficient in how to control inlet system
    + emergency decompression issues

6.4 Issues discussed at Workshop IV

- Concern over us missing the low hanging fruit
  - Attentiveness of humans throughout the system -- ways to measure and interventions to prevent
  - Concern that “design” ovals implies only future, new system design -- no provision for retrofit or procedural changes
  - Current Issue-only Investment Areas are ranked low -- why?
  - Maintenance
    - + people developing NDE inspection equipment need human factors expertise
    - + there is no New Systems or Technology solution for Maintenance shown -- covered by FCSII?
    - + there is an economic incentive for improved maintenance procedures that has not been recognized and factored in the prioritization
    - + some recent accidents have maintenance causal factors -- should rate Maintenance Task Procedures higher
      - > Delta MD-88 @ Pensacola
      - > Valujet @ MIA
      - > Valujet @ ATL
      - > ASA prop blade
    - + as a near-term issue, should be higher than Maintenance Teamwork Procedures & Roles/Responsibilities
    - + CNull: What is the research issue in Maintenance Task Procedures?

      Ans: How do you counter errors in expectation? Person hasn’t seen a crack in 10 yrs, then misses it when it is seen. Is technology the solution?
- Don’t like words “Flight Deck Design and Integration” -- seems too restrictive; perhaps Design and Integration of Human and Aircraft Systems would be better
- Both Boeing and Pratt & Whitney want help with issues associated with “propulsion systems failure followed by inappropriate crew response” (from Romanowski, P&W) -- should be on our list of priorities
- Organizational Culture for Safety should be rated higher
  - studies have shown in strong influence
  - Europeans are way ahead on this, should use their experience/expertise
  - What is the research issue? How to implement and know when it’s working -- PhD’s have written books, but not good info on how to do this right, particularly in aviation; what are relative roles of FAA, manufacturers, and operators; organizations have made changes that most think are good, but there is little structured guidance on what to do; read “Normal Accidents” book
- Design to support Performance Readiness should be part of H/A Design
- There was a sense of this group that there are too many things below the line in Human Error given its apparent role in accident causes (strongly stated by Bozin, ATA)
- Bill Bozin (ATA) endorsed relative rating of HUMAN vs TASK training
  - today we don’t have a problem with selection and skill level

7.0 Written Comments Received and Recommended Disposition

If you are a member of the ASIST Human Error Consequences subteam, contact Doug Arbuckle via e-mail (see address on first page of this report) to receive a copy of the material in this section.